(19) Federal Republic of Germany
[coat of arms]
German Patent Office

(12) **Submission Paper**
(10) **DE 401809430 A 1**

(51) Int. Cl. 5;
F 01 B 9/02

(21) File number: P 40 18 943.0
(22) Registration date: 13. 6. 90
(43) Submission date: 19.12. 91

[vertical:]
DE 4018943 A 1

(71) Registrant:
Krauch, Helmut, Prof. Dr. rar. nat., 6900 Heidelberg DE; Maurer, Thomas, Dip.-Ing., 3501 Fuldatal. DE

(72) Inventor:
same as registrant

(54) Piston engine

(57) In the implementation of the regenerative cycles in a piston engine, the efficiency and performance is improved by a special transmission and by bringing the actual time lapse of the piston action closer to the ideal progression. This transmission, as shown in the example, can be implemented as a crank grind gear. Crankshaft 10 is connected tightly to piston rod 9 and configured across from it and coaxially to the piston rod with linear guiding 11. Sliding block 12 slides in the crank grind 10, in which the eccentric cam 13 rotates with eccentricity E. This eccentric cam is in turn pivoted with eccentricity H in cheek 14 of crankshaft 15. Cogwheel 16 is tightly connected to eccentric cam 13, which is meshed with an equal-sized cogwheel, which is tightly connected to the engine frame 17 and coaxially configured with the crankshaft 15.

Description

The invention is a piston engine designed specifically for the implementation of regenerative cycles, such as the Stirling-process or Vuilleumeur process. The engine can be implemented as a heat engine, heat pump, single or multi-speed radiator, or as an engine which allows a mixture of Stirling and Vuilleumier processess for the freely adjustable, simultaneous provision of heat, coolant and mechanical operation. These kinds of engines are characterized by:

-A closed operating system without ventilation, in which the working agent, which circulates in the thermodynamic process, is permanently enclosed.

-The presence of heat exchangers through which the thermal flow of the transmission is supplied, and the waste heat is drawn out.

-The presence of at least one thermal regenerator which absorbs heat at least once during the cycle and buffers it, and later gives it off. Through this, reversible cycles are made possible.

There are various state-of-the-art designs which affect the above-mentioned engines and transmissions, for example: engines with in-line or v-configuration cylinders often with crosshead gears; engines with in-line or flat configuration (Boxer) with rhombus gears; engines with staggered or swashplated gears and parallel configuration on a circular pitch.

Additionally, various configurations of crankshafts, Parsons gears, as well various rotary and circular pistons designs were suggested.

So-called "free piston engines" are in a category unto themselves. In their case, at least one piston action is activated such that it forces oscillation by means of gas power, specially designed springs, and its own inertia, the path-time relation of which is designed specifically for the realization of the desired thermodynamic process.

In addition to this, a magnetic connection between a piston that has been configured in a hermetically sealed container, or cylinder and a gear installed outside of said container has been suggested. This connection should not to be fitted tightly, but should allow for slippage, the extent of which continuously changes, and the polarity of which varies at its dead center point.

All of these engines share a common problem: the time lapse of the piston action is suitable for only a few limitations in the implementation of the desired reversible regenerative cycles. The movement of the pistons is determined prevalently by the mechanical peculiarities of the gear being used, and stray more often than not from the ideal progression.

Consequently, as in the case of the Stirling-process, for example, a certain amount of operating agent is found, even during the compression phase, in the heated space and during the expansion phase in the cold space. Therefore, the goal of compressing the work agent in low temperatures and expanding it in high temperatures in order to achieve maximum results can not be reached. The supply and removal of heat does not occur at the most advantageous times during the cycle. As a result of the irreversibility caused, the performance and efficiency are theoretically lower possible.

The purpose of the invention is to give off power, enabling the time lapse of the piston action to approach its optimal performance, like that resulting from an ideal Stirling-process in the form of discontinuous piston action. The efficiency and the performance of the above-mentioned can thusly be improved.

An example of the invention in action is demonstrated in Fig. 1 and 2 showing a heat engine being operated according to the Stirling-process. The Stirling motor implemented is an A-type: the hot and cold operating spaces are each formed by a piston in separate cylinders connected by the heat exchanger heater, regenerator and radiator.

In Fig. 1, the expansion piston, which moves within expansion cylinder 2, is labeled I. Compression piston 3 moves within compression cylinder 4 in the same way. Working space 5, in which the operating agent in gaseous form is enclosed, consists of both spaces formed by both pistons in the cylinders and the heat exchanger heater 4, regenerator 7, and radiator 8. A connection between the piston and the gears appropriate for the demand is best achieved by piston rods 9.

Fig. 2 shows a good example of a crank gear transmission. The crank gear 10 is rigidly connected to piston rod 9, which is located opposite and co-axially configured with the piston rod and the linear guiding. Sliding block 12 slides in crank gear 10, in which the eccentric cam revolves with eccentricity 13. This eccentric cam is in turn pivoted with eccentricity 13 in cheek 14 of the crankshaft 15. Gear-wheel 16 is connected tightly to eccentric cam 13 which is meshed to gear-wheel 18, which is the same size and coaxially configured to crankshaft 15 . By this means, the eccentric cam travels on an almost heart-shaped orbit boldly marked in Fig 2.

Fig. 3 shows the evolution of this orbit (dashed) in comparison to the optimal lift function used in the Stirling-process with discontinuous piston action (solid), and the traditional lift function (dotted), used in a crank or swash plate gear.

The relationship of eccentricities E/H lies between 0.1 and 1, and must be fitted or optimized, according to the engine's task. Accordingly, as in the best-case scenario performance of a Stirling-engine shown here, the displacement of both connected crank gears must be determined. In the case of an A-type construct, the displacement corresponds to the lag between the temporal changes in volume in the expansion tank and the compression tank.

In the example illustrated, the space between the upper dead spaces of both pistons can lie between 50° and 160° degrees.

Contrary to the usual state of the art transmission models, a change in the piston displacement (in this case identical with the phase displacement), does not change the geometric compression ratio. In the past, a compromise between optimal efficiency phase displacement and the compression ratio with regards to the desired high compression ratio had to be made.

Connection between the crank pin of the eccentric cam and the piston, when a connecting rod of sufficient length is used (crank ratio λ <0.25), can occur also with a connecting rod, and, for example, a cross head and piston rod, or directly by the connecting rod.

The coupling of two crank gears specifically fitted for the invention, as shown in the example, can certainly occur through a rigid axial coupling of both crankshafts by cogwheel, chain, or belt gear. When choosing the crank displacement, the relative rotation direction of both crankshafts must be taken into consideration.

The engines suggested above are, of course, open to the usual equalization of balance for piston engines.

Patent claims

1. A piston engine, specifically a Stirling engine, which can operate as a heat-powered engine, heat pump or radiator; or as a heat pump or engine that operates according to the Vuilleumier process, providing simultaneous heat and/or radiator and mechanical output. A piston engine characterized by the fact that an optimal time relationship for the implementation of regenerative heat processes is produced between the action of at least one piston and the rotation of one crankshaft, for example, by a revolving eccentric cam gear.

2. The piston engine of claim 1, characterized by the fact that the action of one piston (1.3) is determined respectively by a shaft (15) inside which an eccentric cam (13) with eccentricity E (installed with eccentricity H), is rigidly connected by a cogwheel, which meshes with an equal-sized cogwheel connected to the engine body, installed to rotate within the sliding block, which is connected by a piston rod, which in turn slides in the crankshaft, causing an almost heart-shaped eccentric cam orbit, thus optimizing the regenerative heating process.

3. The piston engine of claims 1 and 2, characterized by the fact that the kinematic connection between lift-cog and piston is not produced by a crankshaft, but by a connecting rod, or by a connecting rod, crosshead and piston rod. The advantages of the invention in terms of time lapse of the piston movement are contingent upon the implementation of a connecting rod of sufficient length (crank ratio λ <0.25).

4. The piston engine of claims 1, 2 and 3 characterized by the fact that the two shafts, which determine the movement of two pistons, [illegible] or belt gear or are rigidly coupled, whereby a phase displacement of 50° and 160° crank angle can be provided between the lift gradients of the pistons. –

5. The piston engine of claims 1,2,3 and 4, characterized by the fact that the balance of the force and momentum of the parts in motion happens in a known manner by counterbalances on the rotating engine parts and/or by the additionally supplied and utilized differential shafts.

Attach 3 pages of designs here.

Number: DE 40 18 943 A1
Int. Cl.[5]: F 01 B 9/02
Date of Submission: December 19, 1991

[design:]

Number: DE 40 18 943 A1
Int. Cl.^5: F 01 B 9/02
Date of Submission: December 19, 1991

[designs:]

[below designs, vertically:]
Orbit of the eccentric cam

Figure 2

Number: DE 40 18 943 A1
Int. Cl.$^{5:}$ F 01 B 9/02
Date of Submission: December 19, 1991

Lift of the expansion piston [chart] — ideal lift range
[chart] - - lift range with orbiting eccentric cam
[chart] .... normal crank lift or swash plate gear
Crank angle in degrees

Figure 3